CHAPTER 12

Genetics and

Getting Ready...

- What characteristics have been passed from one generation to another in your family?
- What environmental factors might affect the development of a fetus?
- What determines whether a baby will be a girl or a boy?
- How does overexposure to the Sun affect cells?
- What is the Human Genome Project?

Science Log

Look for an ad or article about genetic research in plants or animals. If possible, cut it out and paste it into your Science Log. Consider what point the ad or article is making and write a summary statement.

Can you roll your tongue? Are your earlobes detached? Can you bend back your thumb? These are just a few of the characteristics that you may have inherited. In fact, millions of combinations of characteristics are passed from one generation of a family to the next. Study the photograph of the extended family. What characteristics do you think the grandparents passed to the children?

People can also inherit certain disorders. In this chapter you will learn more about heredity and some inherited disorders.

Recently, scientists identified all of the characteristics that make up human beings. Now they are studying diseases caused by alterations in genetic make-up. You will investigate some issues related to these advances in research.

The environment plays a significant role in human development and health. Exposure to environmental elements may cause changes in inherited characteristics. For example, what an expectant mother eats, drinks, or breathes may affect her unborn child. You will investigate the effects of environmental factors on health.

As you learn about heredity and see what a complex combination of traits you have, you may decide to trace some traits in your own family.

Health

What You Will Learn

In this chapter you will learn:

- how physical characteristics are inherited in humans
- how chromosomes determine the sex of a child
- how genetic information is organized in the cells of your body
- about human diseases that result from changes to genetic make-up
- about ethical and social issues related to genetic research

Why It Is Important

- Some babies are born with disorders that could have been prevented. Identifying the risk factors that may cause preventable disorders can help you protect your health and the health of children born in the future. This is important for both males and females, since both provide genetic material to the fetus.

Skills You Will Use

In this chapter you will:

- use techniques to illustrate and interpret hereditary characteristics
- predict the occurrence of some characteristics passed from parents to offspring
- construct a model of how genetic information is organized in cells
- investigate the effects of changes in genetic make-up
- identify points of view about issues related to genetic research

Starting Point ACTIVITY

Which Characteristics Are Most Common?

Discover the most common inherited characteristics in your class.

What to Do

1. Work with a partner. Use the worksheet your teacher provides to complete a chart of human characteristics.
2. Consider both options for the expression of each characteristic.
3. Repeat Step 2 using the other traits on the sheet provided by your teacher.
4. Calculate what percentage of your class exhibits each form of each characteristic.

What Did You Discover?

1. Draw a circle around the characteristics that are most common in your class. For example, if most students in your class have brown hair, place a circle around Option 1, brown/black.
2. Which of the most common characteristics do you share?
3. Study the data you collected on hair colour. How do the totals for Options 1 and 2 compare? Are they nearly equal? Or is one total much larger than the other? If one is much larger, which one?
4. What might you conclude about the occurrence of Option 1 and Option 2 characteristics?

12.1 Structure of DNA

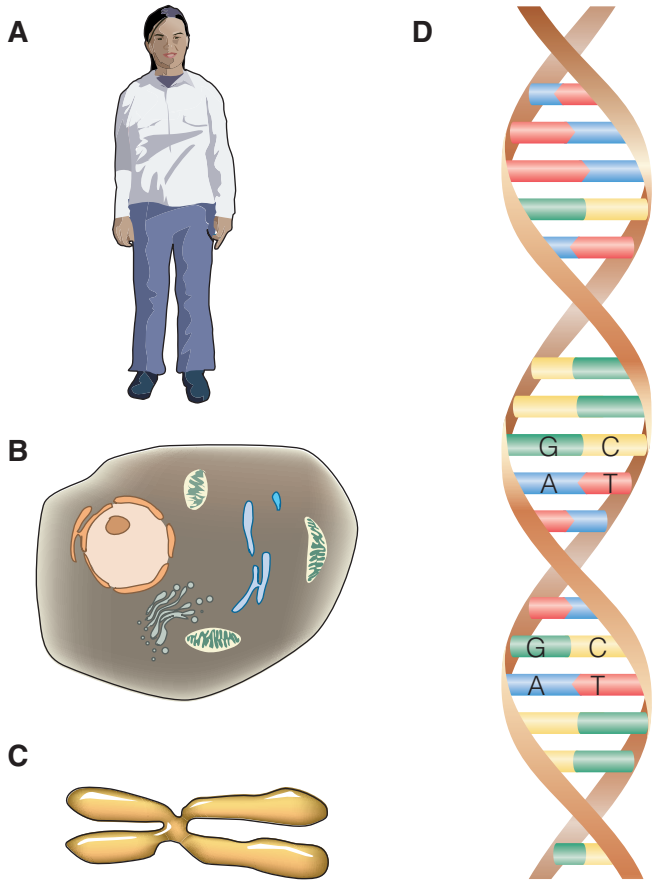


Figure 12.1
A. Your body contains about 10 trillion cells.
B. Each cell contains a nucleus with **chromosomes**.
C. Each chromosome consists of double-helix shaped molecules of DNA. This chromosome has an identical copy attached because the cell has just divided.
D. DNA is divided into segments called **genes**. These control or determine inherited traits.

READING Check

Study Figure 12.1, and then explain the purpose of chromosomes and genes.

People may have told you that you look like your mother or dad — or perhaps a grandparent. Do you know how these characteristics get passed down to you?

The answer involves a branch of science called **genetics**. Genetics is the study of how characteristics or traits are passed from parents to offspring.

To understand how you ended up with the traits you did, think about how your body is made up of systems, organs, tissues, and cells. The unique code for your genetic make-up is stored in the nucleus of each one of these cells. Figure 12.1 explains how your genetic information is organized. Study the four parts of the diagram.

READING Check

Draw a picture to show how DNA is organized.

The Structure of DNA

Look closely at how the DNA is organized in part D of Figure 12.1. Notice that it appears as a twisted ladder. Look at the rungs on the ladder.

Chemical compounds called bases make up the rungs. A pair of bases forms each rung. One molecule of DNA contains about three billion base pairs.

Different genes are made up of different arrangements of these base pairs. The sequence of the base pairs determines the traits you inherit.

Chromosomes

Human body cells contain 46 chromosomes arranged in 23 pairs that hold all the genetic information. One chromosome of each pair comes from the mother and the other chromosome of each pair comes from the father.

Figure 12.2 describes how scientists study chromosomes. First, they group them into pairs, and then they organize them by size, beginning with the longest pair. The sex chromosome pair is organized last. In humans, there are two kinds of sex chromosomes: X and Y. The Y chromosome is found only in males. Females have XX chromosomes. Males have XY chromosomes.

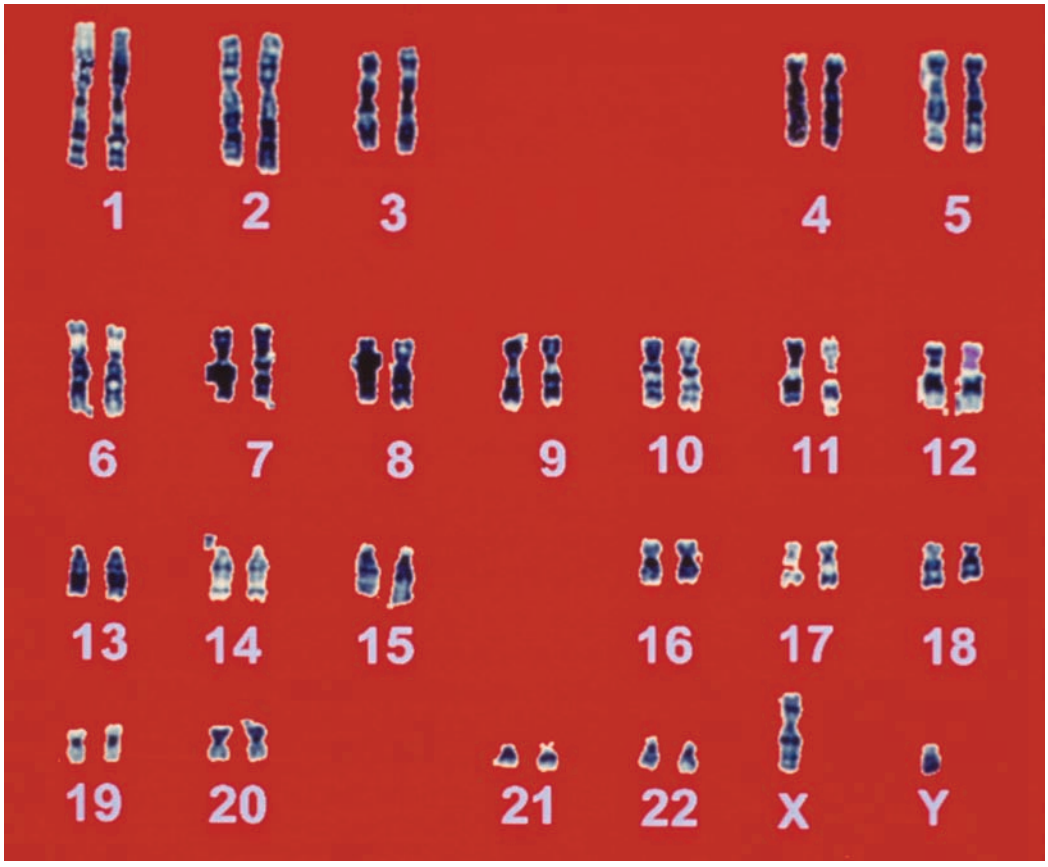


Figure 12.2 Scientists put a sample of white blood cells that are dividing under a microscope and take a photograph. They use the photograph to make a chromosome map like the one shown here. Note that the chromosomes are grouped in numbered pairs according to their size and shape.

Find the pair of sex chromosomes. How large is the X chromosome compared to the Y? Does this map represent a male or a female? How do you know?

Internet CONNECT

www.mcgrawhill.ca/links/science.connect2

Use the Internet to find out how DNA makes an exact copy of itself every time a cell divides. Go to the above web site, then to Internet Connects, Unit C, Chapter 12, and then to DNA Workshop.

READING Check

What chromosome combination determines the sex of human offspring?

Off the Wall

DNA fingerprinting helps scientists identify criminals and victims, because individuals have distinct fingerprints. This is true for humans as well as for other species, such as chimpanzees and apes.

DidYouKnow?

The DNA of all people on Earth is 99.9 percent identical. It is the 0.1 percent difference that makes each one of us unique.

Try This!

Use toothpicks, four different colours of marshmallows, and licorice rope to model DNA. Use the licorice rope to make the sides of the ladder and the marshmallows to make the base pairs that form the rungs. The toothpicks can work to connect the bases and the licorice.

CONDUCT AN

INVESTIGATION 12-A

SKILL CHECK

- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Who Is the Father?

You have a purebred female dog who just had puppies. Your female was bred to a very popular and expensive stud dog. Later, she got loose and was around another stud that is not so well known. You are not sure which dog fathered the puppies.

Scientists use a test like the one you will do here to determine the father of the puppies. This will decide who the father is — and therefore how valuable the puppies are.

Problem

Who is the father?

Safety Precautions

- Be careful around boiling water.
- Clean up the work area and wash your hands thoroughly at the end of the investigation.

Apparatus

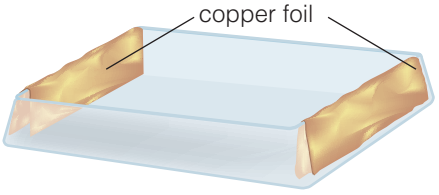
soap dish (approximately 7 cm x 10 cm x 3 cm)
150 mL beaker
scale
metal stirring spoon
hot plate
oven mitts
1 mL capillary tube or very small pipette
wire leads (red and black)
5 batteries (9 V)

Materials

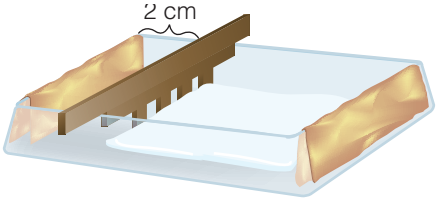
copper foil
polystyrene foam
175 mL pH 8 buffer solution
1 g agar
4 pieces masking tape
4 small test tubes, each containing a DNA sample (approximately 5 mL) from the mother, a puppy, or one of the two male dogs

Procedure

1. Working with a partner, line each end of the soap dish with copper foil as shown in the illustration. Make sure the foil touches the bottom of the inside edge.



2. Make a comb out of polystyrene foam, using the template your teacher provides.
3. Measure 100 mL of the buffer solution in the beaker. Use a scale to weigh 1 g of agar. Add the agar to the beaker and stir to mix.
4. With the hot plate on medium, bring the solution in the beaker to a boil. Continue boiling until the agar dissolves and the solution becomes clear. Stir occasionally to help dissolve the agar.
5. Put on the oven mitts to protect your hands. Pour the agar solution carefully into the soap dish.
6. Hang the comb about 2 cm from one end of the soap dish. Make sure the bottom of the comb is not touching the bottom of the soap dish.



7. Allow 10 to 15 minutes for the agar solution to cool. As it does, the teeth of the comb will make four depressions or well sites.
8. Once the agar has set, gently shake the comb and remove it from the soap dish. This will leave four depressions or wells.

9. On small pieces of masking tape, write the name of each of the DNA donors: mother, puppy, stud 1, stud 2. Put the tape on the work surface near the soap dish to identify each well site.

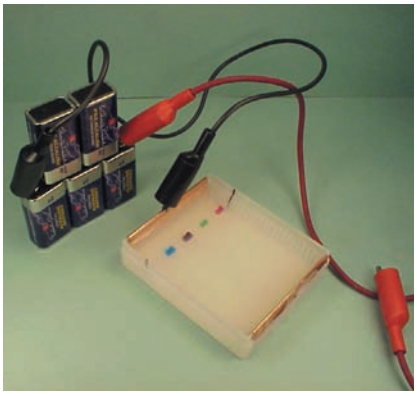
10. Pour 75 mL of buffer solution on top of the agar.

11. Use the capillary tube to squirt a drop of each DNA sample into the well site with the matching label. Be sure not to overfill the well sites or spill the samples into the agar. Carefully rinse the capillary tube between each DNA sample.

12. Arrange the batteries in series by matching a positive terminal with a negative terminal as shown. The batteries will form a two-tier pyramid shape.

13. Attach the black (-) lead to the end of the soap dish nearest the wells.

14. Attach the red (+) lead to the opposite end of the soap dish. Do not touch while the batteries are connected.



15. Record your observations after 15 to 20 minutes.

Analyze

1. What happened to the DNA samples in each well?
2. Which DNA sample travelled the longest distance? The shortest distance?
3. Why do you think it was important to rinse the capillary tube between each DNA sample?

Conclude and Apply

4. Who is the father of the puppy?
5. How did you reach your conclusion?
6. How was it helpful to work with a partner? How could you improve your work with a partner?

Check Your Understanding

1. What is genetics?
2. Develop a concept map explaining the relationship between DNA, genes, cells, a cell's nucleus, and chromosomes.
3. Draw and label a model of DNA that includes eight base-pair "rungs."
4. **(a)** How many chromosome pairs do humans have?
   (b) Name the chromosome that a male has that a female does not.

Key Terms

genetics
chromosomes
DNA
genes

12.2 Inheritance and Genetics

Internet CONNECT

www.mcgrawhill.ca/links/science.connect2

Use the Internet to find out more about Mendel's work. Go to the above web site, then to Internet Connects, Unit C, Chapter 12, and then to Mendel and DNA.

Half of your genetic make-up comes from your mother and the other half from your father. Then why don't all brothers and sisters look alike? How do traits skip generations?

The answers to these questions have to do with **heredity**, which is the passing of characteristics from parents to offspring.

During the mid-1800s, Gregor Mendel, an Austrian monk, experimented with pea plants to show that traits do not happen by accident. He noticed that pea plants vary in height. Some are tall, others short. He crossed tall and short pea plants to see how height would be affected in the offspring.

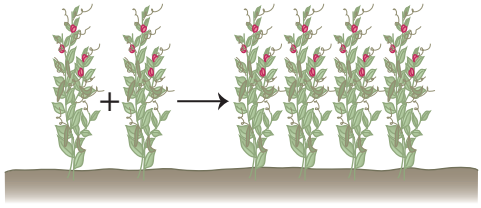
READING Check

What is heredity?

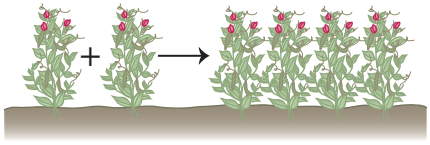
Mendel recorded the traits of the offspring plants over several generations. Figure 12.3 summarizes what he discovered about the trait of tallness in pea plants. Study the pictures and read the captions to help you understand the difference between dominant and recessive traits.

During the Starting Point Activity on page 211, you surveyed what traits appear most often in humans and which traits appear less often. Read the caption with Figure 12.3 and notice the definition for a dominant and a recessive traits. Go back to your survey and identify the traits that were dominant and recessive.

Figure 12.3

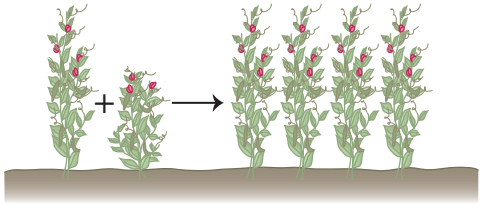


A. tall parent + tall parent = pure tall plants

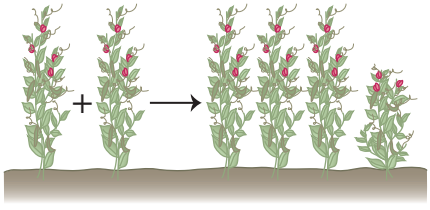


B. short parent + short parent = pure short plants

• Mendel looked at the results of the crosses shown in A and B. He referred to the parent plants as purebreds. **Purebreds** have identical genes for each trait. In this case, the parents in A and B had identical genes for tallness.



C. pure tall parent + pure short parent = hybrid tall plants
• When Mendel crossed the pure tall plants with the pure short plants, the offspring were always tall. The short trait seemed to disappear.
• Mendel called tallness a **dominant** trait because it seemed to dominate the short trait.
• He called shortness a **recessive** trait because it seemed to disappear.
• Offspring of this cross are called hybrids. **Hybrids** carry one gene of each kind for each trait. In this case, they carry one gene of each kind for tallness.



D. hybrid tall plant + hybrid tall plant = mix of tall and short plants (3 tall, 1 short)
• Mendel crossed hybrid tall plants with hybrid tall plants. He was surprised to discover that sometimes shortness appeared in the offspring.
• From these observations, Mendel concluded that tallness must be controlled by factors inherited from both parents.

Recording Inherited Traits

Since chromosomes come in pairs, genes for traits do too. Many traits are controlled by only one pair of genes, others by two or more pairs.

For traits controlled by one pair of genes, geneticists use two letters to represent the **genotype** or combination of genes.

- Capital letters represent dominant genes. For example, the letter T could represent the dominant gene for tallness, which is the *tall* gene.
- Lower case letter represent recessive genes. For example, the letter t could represent the recessive gene for tallness.

During reproduction, chromosomes separate so that each sperm or egg cell gets only one chromosome of each kind. As a result, only one gene for each trait is passed on to the offspring from each parent.

Figure 12.4 This lowland gorilla has no pigment or natural colouring of its skin, eyes, or hair. Such an individual is called an albino. Albinos have inherited two recessive genes. They have two copies of the gene for albinism and no copy of the gene that makes normal pigment.

Punnett Squares

Geneticists use a **Punnett square** to predict the probability of offspring inheriting certain traits. Figure 12.5 shows the results of crosses in Figure 12.3.

A

	T	T
T	TT	TT
T	TT	TT

B

	t	t
t	tt	tt
t	tt	tt

C

	T	T
t	Tt	Tt
t	Tt	Tt

D

	T	t
T	TT	Tt
t	Tt	tt

Figure 12.5 Describe the appearance of each offspring in A, B, C, and D. Why were there no short plants in C, even though one plant was short?

Note that:

- the possible genes in the eggs from the female are across the top;
- the possible genes in the sperm from the male are down the left side; and
- the possible gene combinations of offspring are shown in the four squares.

There are four possible gene combinations in the offspring. Look at the offspring in Punnett squares C and D. Mendel used results like these to show that recessive traits can skip generations.

In Punnett square C, shortness did not appear in the offspring because tallness is dominant. However, shortness reappeared in the next generation (Punnett square D). This occurred because one of the offspring inherited two genes for shortness.

READING Check

Why do scientists use a Punnett square?

READING Check

If C is the dominant gene for hair colour, and c is the recessive gene, describe three genotypes.

Try This!

Females have XX genotype. Males have XY genotype. Complete a Punnett square to discover the chances of giving birth to a male or female child.

READING Check

What is a pedigree used for?

Pedigrees

A type of scientist called a geneticist uses a tool called a family tree or **pedigree** to trace traits in a family. A pedigree is a diagram that shows the history of a trait from generation to generation. Pedigrees show traits with different characteristics, such as long eyelashes or short eyelashes, through many generations. Plant and animal breeders use the information from pedigrees to increase the chances of breeding plants and animals with only desirable traits.

Find Out ACTIVITY

SKILL CHECK

- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Interpreting a Pedigree

Your teacher will provide you with some information about pedigrees and specific information about one family. You will use this information in doing this activity.

What to Do

1. Use the worksheet that your teacher provides to complete the activity.

What Did You Find Out?

1. Write a concluding statement about the chances of inheriting dimples in the Lee family.
2. Why should you include as many generations as possible when you make a pedigree?
3. Assume that Mrs. Lee has Dd genotype. What genotype must Mr. Lee have? Make a Punnett square to show the possible combinations of traits in the children. Does the pedigree agree with what you found? Why or why not?

Disc CONNECT

To learn more about the inheritance of genetic traits, using a Punnett square, and interpreting pedigrees, load the student CD-ROM onto your computer. Launch the **Genetics** applet and follow the instructions.

Career CONNECT

Think about a career in horse or dog breeding, especially if you enjoy animals and are a keen observer of features such as coat condition, size, alertness, strength, and temperament.

Go to breeding establishments and shows to learn about the standards for the breed that interests you. Find out how breeders use pedigrees to improve bloodlines and how they test for genetic disorders to avoid passing on problems.

For such a job, you need good communication skills, an empathy for animals, and an understanding of basic genetics. Most positions offer training right on the job!

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                SIRE: GREENWOOD DACAPO
PAJE DAK-A-BOY  -0030610- -                GREENWOOD CARUSO 0236605 US
0031546-
                DAM: TRAVERSTON TAFITA     PRINCESS ROSALIE 0052213 US
                -0022261-
                                           GIGI FIX -0007473-

                                           ALLENS PRINCESS -0026895-
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GWALIOR 0036089 US
WINDBORNE CAPRI 0129500 US
BASKE-TU 0031828 US
ROSALIE 0020794 US
IBN HATHFAN -0002250-
CELLUCCI -0001342-
TEARRA FIX 0043623 US
GAY FAYRAD -0011154-
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Figure 12.6 Dog and horse owners study the pedigrees of animals they are thinking of buying or breeding. For example, if they want an animal with endurance, they will look for ancestors that show the same trait.

DESIGN & DO

INVESTIGATION 12-B

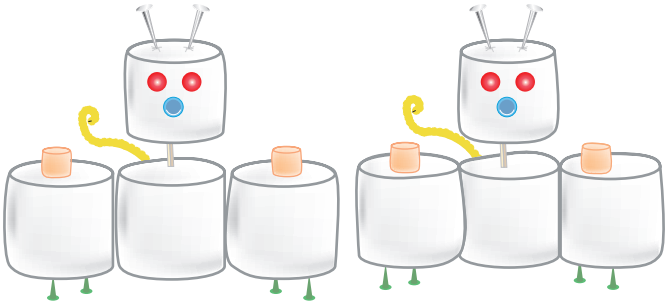
SKILLCHECK

- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Produce an Offspring

Challenge

Produce an offspring from genetic information provided by two parents.



Mallow father Mallow mother

Safety Precautions

- Use caution when using sharp, pointed objects such as thumbtacks and pushpins.
- Clean up the work area and wash your hands thoroughly at the end of the investigation.
- Do not eat in the science classroom.

Apparatus

scissors
small nails
thumbtacks
pushpins
markers or pastels

Materials

pipe cleaners (one colour)
large white marshmallows
miniature orange marshmallows
toothpicks
glue sticks

Design Criteria

A. Use genetic information to produce an offspring. Use markers or pastels to colour the thumbtacks and pushpins.

B. Make random choices to determine the traits of the offspring.

C. Develop a chromosome map of the offspring.

D. Use the materials to create the offspring.

Plan and Construct

1. With a partner, observe and record the physical features of the Mallow parents. Each parent has one dominant and one recessive gene for each trait. Record the genotypes for each trait.
2. Randomly choose one chromosome from each of the parent's chromosome pairs to make the new chromosome pair for the offspring.
3. Make a chromosome map on a separate sheet of paper.
4. Record the genotype for each trait. Record the physical features of the offspring.
5. Do the analysis provided by your teacher.

Check Your Understanding

1. How do you inherit characteristics, such as eye colour, from your parents?
2. Why is a Punnett square a useful tool for geneticists?
3. Can you tell the difference between tall plants with the genotype TT and tall plants with the genotype Tt just by looking at them? Explain.

Key Terms

heredity
dominant
recessive
hybrid
purebred
genotype
Punnett square
pedigree

12.3 Genetic Changes

READING Check

Explain how inherited and environmental mutations can occur.

Most of the time the process of cell reproduction and copying genes works well. Mistakes, however, can happen during reproduction when chromosomes are copied. In most cases, body cells recognize errors and fix them. In other cases, a cell's repair mechanisms can fail. These mistakes are then passed from generation to generation.

Such changes in genetic information can result in an abnormal gene called a **mutation**. Mutations can occur in several ways. Figure 12.7 shows how the change in one of the base pairs of a gene can lead to sickle-cell anemia.

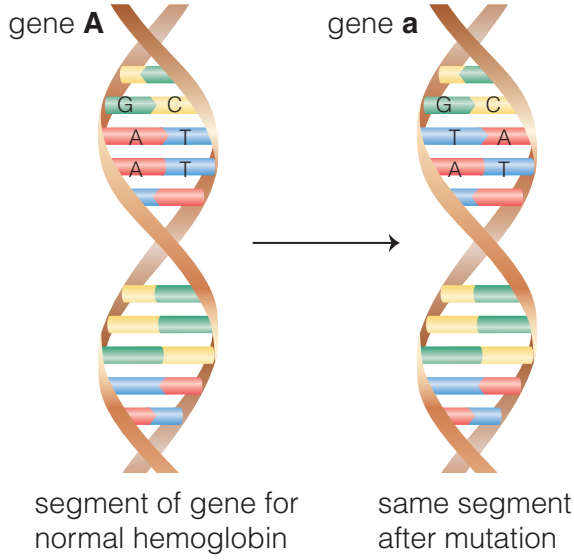


Figure 12.7 Look at the pairs in gene **A** and gene **a**. How do they differ? Gene **A** produces normal hemoglobin. Gene **a** produces defective hemoglobin which causes sickle-cell anemia.

Try This!

Use Punnett squares to determine the chances for each of the following sets of parents having a child with sickle-cell anemia.

(a) one parent carries the gene (Aa x AA)
(b) both parents carry the gene (Aa x Aa)
(c) one parent carries the gene and the other has the disease (Aa x aa)

For each set of parents, what is the chance of having a child with sickle-cell anemia?

READING Check

Name and describe one genetic disorder.

Exposure to environmental factors can also cause mutations. Environmental factors that cause mutations are called **mutagens**. These include radiation; ultraviolet light; and many chemicals, including PCBs, those in cigarettes, and alcohol and other drugs.

Most of these errors do not pass from one generation to the next. There are exceptions. For example, children may pass on some effects from their mother's exposure to radiation.

DidYouKnow?

Huntington's disease usually starts in middle age and slowly destroys physical and mental abilities. In their search for the cause of this disorder, researchers are studying a pedigree that includes nearly 10 000 people of an extended family in Venezuela.

Inherited Genetic Disorders

Sometimes, a mutation may be helpful. For example, giraffes with a mutation for a longer neck increase their ability to obtain food. Usually mutations result in **genetic disorders**, which result from alterations to the genes. For example, sickle cell anemia results from an abnormal form of hemoglobin. Hemoglobin is the substance in red blood cells that carries oxygen through the body. Someone with sickle cell anemia has abnormal hemoglobin. This leads to poor resistance to infection and low levels of iron in the blood.

CONDUCT AN

INVESTIGATION 12-C

SKILL CHECK

- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Are Your Genes or Environment More Important?

Which do you think is more important — genetics or environment? In this investigation, you will use corn seeds to determine the importance of these two factors in the growth of corn plants.

Problem

What effect does genotype have on plant development?

What effect does light have on plant development?

Safety Precautions

- Clean up the work area and wash your hands thoroughly at the end of the investigation.

Apparatus

2 petri dishes

pencil

Materials

corn seeds

water

labels

paper towels

Procedure

1. Work with a partner. Place a damp paper towel in the bottom of each petri dish.
2. Spread 10 corn seeds in each petri dish. Assume that your seeds are produced from genotype Cc parents, with C dominant for green and c recessive for albino traits.
3. Cover and label each petri dish with your name and one of the following environments: Dark, Light.
4. Place one petri dish in a location with good light. Place one petri dish in a location that has no light source. Maintain the same temperature conditions for each dish. Check both dishes daily for signs of growth.
5. After the seeds have begun to sprout, use the worksheet to record your results.
6. Leave both petri dishes in a location with good light for three more days. Moisten the paper towel if necessary.
7. Use the worksheet to record your results.

Analyze

1. Do the analysis provided by your teacher, and then answer the questions that follow.

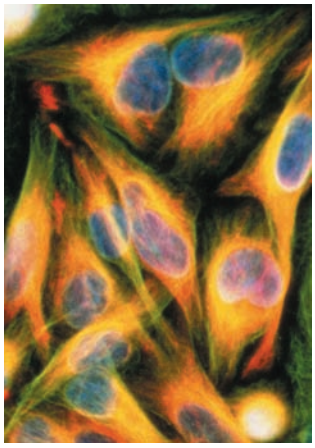
Conclude and Apply

2. From what you observed, what can you say about the chances of survival of an albino seed?
3. Based on your observations, explain how a change in light conditions can affect the appearance of a plant.
4. Corn plants need the right genes and light in order to produce chlorophyll. Do your results agree with this statement? Explain why or why not.

Extend Your Knowledge

5. Which factor is more important for the survival of a plant — heredity or environment? Take a position. Provide reasons for your opinion.

Genetic Disorders Caused by Mutagens



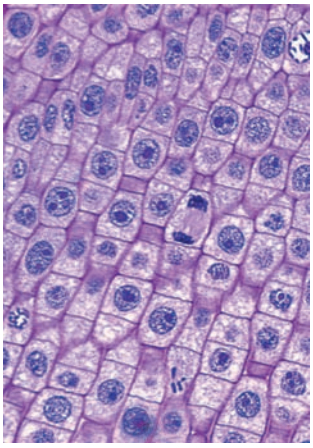


Figure 12.8 Radiation alters the DNA in normal cells to form cancer cells. The cancer cells keep dividing and build up masses of tissue called a tumour.

Radiation from X-ray machines and ultraviolet light in sunlight or tanning lamps can cause mutations. Such radiation releases particles smaller than atoms into cells and causes chromosomal changes. An overdose may cause cancer, skin burns, and other serious conditions.

Doctors use radiation beneficially to treat diseases such as cancer. They focus large doses of radiation on the cancer cells in an attempt to destroy the cell nuclei. Damage to non-cancerous tissue is limited by shielding the healthy tissue from radiation. The amount of radiation is also carefully monitored.

Human embryos are particularly at risk from exposure to mutagens. Table 12.2 examines some dangerous chemicals and their effects on human embryos.

READING Check

Name three mutagens that harm human embryos and describe the effect of each.

Table 12.1 Mutagens and Effects on Human Embryos

Mutagen	Effect
Exposure to alcohol • Children born to mothers who consume any alcohol during their pregnancy may suffer from a condition called fetal alcohol spectrum disorder (FASD).	• low birth weight • facial and joint abnormalities, small heads • heart defects • difficulties with learning, behaviour, and mental health
Exposure to prescription and illegal drugs • Pregnant women should take prescription drugs only under a doctor's care. Doctors who know the woman is pregnant look for medications that do not harm the fetus.	• premature births • low birth weight • drug addiction at birth • possible mental limitations • possible birth defects
PCBs (polychlorinated biphenyls) • PCBs are a mixture of toxic chemicals present in the environment because of improper disposal of wastes and consumer products. Some are linked to various forms of cancer, including liver and kidney cancer.	• low birth weight • mild symptoms that often disappear with age: anemia, liver conditions, skin rashes • difficulties co-ordinating movement and problems with short-term memory that last several years • delays in normal development • problems with immune system

Key Terms

mutation
mutagens
genetic disorders

Check Your Understanding

1. Briefly describe how a mutation might occur when chromosomes are copied. Use a sketch if you wish.
2. **(a)** What are mutagens?
   (b) Name one example of a mutagen and identify a genetic disorder that results from exposure to it.
3. Why is it important that pregnant women avoid consuming any amount of alcohol or taking any type of drug?

12.4 Issues in Genetic Research

Many people believe that the Human Genome Project is the most important scientific effort that humans have ever attempted. All of the genes found in a complete set of chromosomes — the set of genetic instructions that makes you what you are — form a genome. Scientists working on the genome project have mapped where each gene belongs on 46 human chromosomes.

This kind of information has many benefits. One benefit is that scientists can use this knowledge to transfer genes from one organism to another to give one organism the traits of another. Transferring genes from one organism or type of organism to another is referred to as **genetic engineering**. For example, scientists have inserted a spider gene into goats. The goat then produces a protein identical to the protein found in spider silk. The protein is removed from goat milk to produce silk fibres used to make bulletproof vests.

Someone who suspects they have a genetic disorder such as a genetic disposition toward cystic fibrosis or breast cancer, may use genetic research to check their chances of developing a specific disease. They may contact a genetic counsellor, who gathers medical information about the individual's family and analyzes the person's chromosomes to help predict the chances of the person developing a particular disorder.

Table 12.3 outlines some of the benefits of these advances in genetic research and engineering. But there are also concerns, which you will learn about on the next page.

DidYouKnow?

This pregnant woman is having an **amniocentesis**. This procedure is used to determine the chromosomal make-up of a fetus. The test shows whether a fetus may have a genetic abnormality. Some parents use such tests to decide whether or not to continue with a pregnancy. This picture shows ultrasound being used to locate the fetus. Doctors need to know where the fetus is so that they do not damage it when they insert a large hollow needle to withdraw amniotic fluid.

Figure 12.9

Table 12.2 Benefits of Genetic Research

Benefit	Examples
• identifying the source of thousands of genetic disorders (such as colourblindness, hemophilia, or cystic fibrosis)	• If scientists can identify the gene that causes a disease such as epilepsy, they may be able to alter that gene and thus cure the condition.
• developing new drugs and treatments	• Researchers identified the human DNA responsible for insulin production. They inserted that DNA into bacteria. Each time the bacteria cells divide, the human insulin gene is duplicated. The technology produces an inexpensive supply of insulin for people who have diabetes.
• helping people make lifestyle choices	• By studying a family's genes, researchers can determine which diseases people with that genetic make-up are most likely to develop. Someone with a family history of heart disease, for example, might take special care to eat a low fat diet and exercise regularly.

READING Check

Identify at least three benefits of genetic research.

INVESTIGATION 12-D

SKILL CHECK
- Initiating and Planning
- Performing and Recording
- ✸ Analyzing and Interpreting
- ✸ Communication and Teamwork

To Clone or Not to Clone?

Think About It

The scientific community was astonished when Dolly, the first cloned sheep, was born. The success with cloning Dolly sparked a lot of debate about the ethics of cloning other mammals — such as humans. Some people think cloning is a great hope for the future. Others reject the technology as a dangerous abuse of science. Do we have the right to do what is necessary to clone ourselves?

Consider the case of a brilliant scientist who has six months left to live. She is considering whether or not to clone herself so that her intelligence, living in a new body, can be used to continue her work. Use the following guide to help you take a position on cloning humans.

What to Do

1. Work in a small group. Use library and Internet sources to gather information about the issues surrounding cloning humans.
2. **(a)** Read and think about the articles that discuss whether or not we should clone humans.

   (b) Discuss the ideas with your group and family.
3. Make a decision about how you feel.
   - Do you think the scientist should not be cloned? Then say so and explain why. Remember to provide supporting points for your argument.
   - Do you think the scientist should be cloned? Say so and explain why.
4. Write a paragraph that shows your position and your reasoning.
5. Study other people's paragraphs.

Analyze

1. Think about the ideas expressed in the class paragraphs.

   (a) List three points you might support. For each one, provide a reason for your support.

   (b) List three points you reject. For each one, provide a reason for your lack of support.
2. With a partner, evaluate how well each paragraph meets the following criteria:
   - suitable for the audience
   - clear statement of position
   - adequate supporting points

Extend Your Skills

3. Under what circumstances do you think it might be acceptable to clone a human? Explain who might be cloned and why.
4. **(a)** Should genetic engineering be used to choose traits in children?

   (b) Should it be used to correct defects? Consider both sides by suggesting an argument for and against each question.

Computer CONNECT

Use a word processor to organize your arguments for and against human cloning.

Internet CONNECT

www.mcgrawhill.ca/links/science.connect2

Use the Internet to investigate more about a special form of genetic engineering called pharming, and the benefits and drawbacks of this technology. Go to the above web site, then to Internet Connects, Unit C, Chapter 12, and then to Pharming.

Figure 12.10 Scientists do not know all the risks of new technologies. For example, Dolly, the world's first cloned sheep, developed arthritis before she was six years old. Researchers do not know whether Dolly's arthritis was caused by environmental factors or genetic factors.

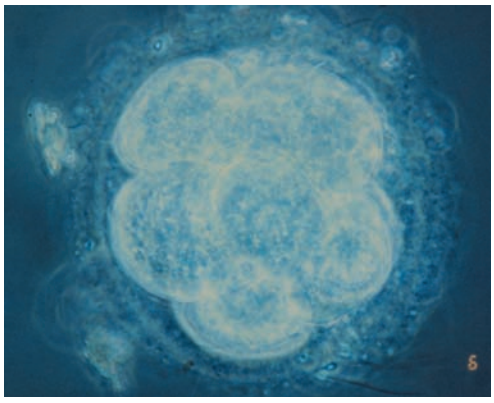


Figure 12.11 Many people question the ethics of using a human embryo such as the one shown here to harvest stem cells. Stem cells are unspecialized cells that are the building blocks for many body parts. Researchers hope to use stem cells to treat a variety of diseases, including Alzheimer's disease, and grow new organs. Is it right to kill an embryo in order to do this?

Concerns about Genetic Research

What would happen if all parents decided to have only male — or only female — children? This is the kind of question people ask when discussing genetic research. Such questions are ethical questions. They consider what is right or wrong.

Some ethical concerns deal with questions about who should have access to genetic information. For example, might employers ask for genetic information about employees? How might they use it?

Consider the ethical issues below, and then identify the ethical concerns raised in Figures 12.10 and 12.11.

- Who has a right to genetic data that provide information about your chances of developing various conditions? What might happen if health insurance companies had access to everyone's genetic make-up? Could they refuse to provide some people with health insurance? What might happen if an employer found out that an employee had genes that often result in substance abuse? Might the employee be fired?
- Do you want to know genetic information that may tell you of a terrible disease you are likely to develop but unable to do anything about? How might knowing this affect the way you live? Might you suffer from depression or adopt behaviours that put you more at risk?

READING Check

Identify two concerns about advances in genetic research.

Check Your Understanding

1. How might amniocentesis create an ethical problem for some people?
2. Working with a partner, list three pros and cons of using advances in genetics. Develop a chart similar to the one shown here to help you organize your information.

Pro	Con

3. Choose one ethical dilemma related to genetic research. Work with a partner to discuss the points of view on this dilemma. Consider how you feel about the issue. Express your point of view orally.

Key Terms

genetic engineering
amniocentesis

CHAPTER

12 Review

Key Terms

genetics
chromosomes
DNA
genes
heredity
dominant
hybrid
purebred
recessive
genotype
Punnett square
pedigree
mutation
mutagens
genetic disorders
genetic engineering
amniocentesis

Reviewing Key Terms

If you need to review, the section numbers show where these terms were introduced.

1. In your notebook, write the correct term or terms to complete each of the following sentences.

(a) The nucleus of each cell contains _____ . (12.1)

(b) The study of how traits are passed from parents to offspring is called _____ . (12.1)

(c) Mutations in the DNA result in _____ _____ . (12.3)

(d) The basic building block of an inherited trait is called a _____ . (12.1)

(e) Down syndrome is a genetic disorder. Genetic disorders can be detected with a test called _____ . (12.4)

(f) An abnormal change in genetic information results in a _____ . (12.3)

(g) A trait that remains hidden for several generations is called a _____ trait. (12.2)

(h) Mendel used pea plants to study _____ . (12.2)

(i) The method often used to trace patterns of inheritance in a family is the _____ . (12.2)

(j) A _____ has identical genes for each trait. (12.2)

(k) Genes consist of arrangements of base pairs in the _____ molecule. (12.1)

(l) Plants that carry one gene of each kind for a trait are called _____ plants. (12.2)

Understanding Key Ideas

Section numbers are provided if you need to review.

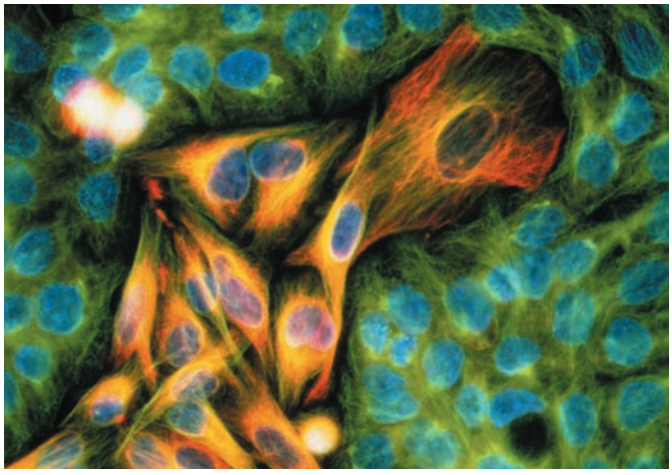
2. Use a sketch to show where genetic information is stored in the cell. Label your sketch. (12.1)

3. (a) Name three traits you inherited.

(b) For each trait, describe the dominant and recessive forms. (12.2)

4. How can a physical trait appear to skip a generation? (12.2)

5. Use this photograph to help explain what happens to the DNA in cells that are exposed to radiation. (12.3)



6. Describe two benefits of genetic research. (12.4)

7. How does genetic engineering help people with diabetes? (12.4)

Developing Skills

8. (a) Explain how chromosomes determine the sex of human offspring. (12.1)

(b) Draw a Punnett square to show all possible combinations of the chromosomes that determine sex. (12.2)

(c) Write a probability statement about the chances of having male or female offspring. (12.2)

9. (a) Detached earlobes are dominant and attached earlobes are recessive. Construct a pedigree for attached and detached earlobes for your family or for a family you choose. Make a key. Include as many generations and as many relatives as you can. (12.2)

(b) Write a concluding statement about the inheritability of the trait in the family shown.

10. (a) What is a gene mutation? (12.3)

(b) Identify one defect caused by a gene mutation in humans.

Problem Solving/Applying

11. Marco, who has curly hair, marries Sylvie, who has curly hair. If curly hair is dominant, can they be sure their children will have curly hair? Explain. (12.2)

12. Nimar and Sue are curious about what their baby will look like. The table shown here outlines three traits they wonder about. Use steps (a) through (d) to predict the possible outcomes of three traits that the baby will inherit. (12.2)

Hair Type	Freckles	Eyelashes
C — curly	F — freckles	E — long
c — straight	f — no freckles	e — short

(a) Decide on your own what Nimar and Sue might look like.

(b) Given your description, decide the genotype for each trait for each parent.

(c) Use a Punnett square to show the possible combinations of each trait.

(d) Write a concluding statement about the baby's chances of inheriting each trait.

Critical Thinking

13. Geneticists use data from many generations of a family to study inheritance. Why do you think they prefer to work with fruit flies instead of elephants? (12.2)

14. Since the arrival of Dolly, scientists have moved closer to cloning human beings. What concerns might people have about cloning humans? (12.4)

Extend Your Understanding

15. Interview a health-care professional. Prepare a list of questions to ask about fetal alcohol spectrum disorder. (12.3)

Pause & Reflect

1. Check your original answers to the Getting Ready questions on page 210. How has your thinking changed? How would you answer these questions now that you have investigated the topics in this chapter?

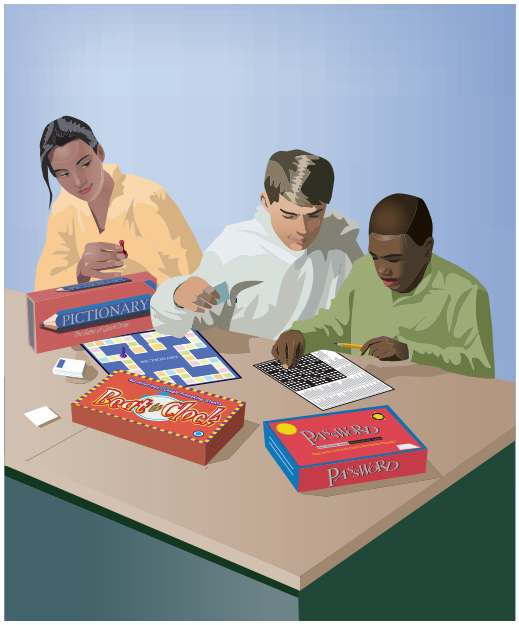
2. A cloned organism has exactly the same DNA as its parent. Think about what you have learned about hereditary and environmental factors. Will the clone be exactly like its parent when it matures?

unit C PROJECT

SKILL CHECK
- Initiating and Planning
- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

A Health Challenge Game

Use what you have learned about disease, heredity, and human health to design and build a game.



Challenge

Work in groups to develop a game that can be played in less than one class period. Make the game exciting and challenging because your classmates will play your game and assess it.

Safety Precautions

- Wash your hands thoroughly and clean up the work area at the end of the activity.

Materials

shoe box

assorted paper or labels

assorted art supplies (for example, glue, tape, scissors, pencils, paints, markers)

game supplies (for example, dice, spinner, timer)

equipment for lights and buzzers, if needed

Design Criteria

A. Choose a game format that is easy to set up.

B. The game needs to accommodate a minimum of two players.

C. The game needs to cover a minimum of 20 key concepts or terms presented in this unit.

D. Develop:
- a list of concepts covered in Unit C,
- a title for your game,
- a detailed plan for making it,
- a list of necessary apparatus and materials, and
- rules and directions for playing the game.

E. The game needs to fit inside a shoe box for easy storage.

Plan and Construct

1. In your group of 2–4, identify the key terms and concepts from Unit C. Use the information to make your game.
2. Brainstorm game designs and choose one.
3. List the materials you will need to construct the game. This should include any game pieces, scoring sheets, game board, and anything else that is required. Decide which ones you already have and which you will design in the group.
4. Write down the rules of your game. Include how a player moves through the game as well as how to determine who is the winner. Write the rules and directions clearly so someone who has never played the game before can follow them.

5. Test your game and directions to be sure no steps are missing. To do this, have one group member read the steps out loud one at a time while another group member carries out each direction. Make changes if necessary.

6. If you have time, repeat Step 5 with someone from another group. Make changes to any steps the new person does not understand.

7. Give your game a title.

8. When everyone is ready, exchange games with another group and have fun!

Evaluate

1. Assess the game your group developed.
   (a) Did your game meet all of the design criteria? If not, what did you miss? Was there a reason?

   (b) What concepts were difficult to incorporate into the game?

   (c) What would you do differently the next time?

2. Did developing a game help you learn the concepts in the unit? Explain why or why not.

3. **(a)** Use the following statements and rating scale to assess the game you played and provide feedback to the game developers.

Rating Scale

5 — "Excellent!"
4 — "Great!"
3 — "OK"
2 — "It needs some work."
1 — "Not really."

Feedback Criteria

- Rules are clear and directions are easy to follow.
- The game is fun and challenging to play.
- Key terms and concepts from each chapter are used.
- The content is accurate.
- The game is neat and well built.

(b) Give the group that designed the game feedback about how well the game met the design criteria. Make constructive suggestions.

4. Take a class poll to find the answers to the following questions. For each answer, provide an explanation for the class choices.
   (a) Which game(s) was the most challenging?

   (b) Which game(s) was the easiest to play?

   (c) Which game(s) was the most fun to play?

   (d) Which game(s) covered the concepts most effectively?

5. How was it helpful to work as a group to make and evaluate a game? How could you improve your group work?

Extension

6. Design a package that promotes your game. Make sure the package highlights some important concepts about human health.

Computer CONNECT

Use a word processor to organize your game.